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GB 2322597 A WO 97/27053 A1 US 5237917 A
WPI Abstract Accession No. 96-185067/19 & JP 08060054 A (Canon) 05.03.96 (see abstract)

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(54) Abstract Title

Method of digital colour inkjet printing on a non-absorbent substrate using ultraviolet curable inks

(57) A printhead 11 ejects jets 12 of ultraviolet curable inks towards an untreated substrate 15 made from a non-absorbent material such as a clear gloss or textured plastic sheet. The substrate is held on a drum 14 which rotates to expose the substrate to an ultraviolet light source 16 to cure the ink on the substrate. Each time the substrate passes beneath the printhead, ink of a different colour is ejected onto the substrate. The substrate is subsequently exposed to the ultraviolet light on each drum rotation to ensure the ink is cured before the next colour is applied. The substrate may be removed from the drum and exposed to a second curing source (10,Fig.1) if necessary to ensure the ink is permanently fixed on the substrate. The method may be used in, for example, a direct digital colour print process.

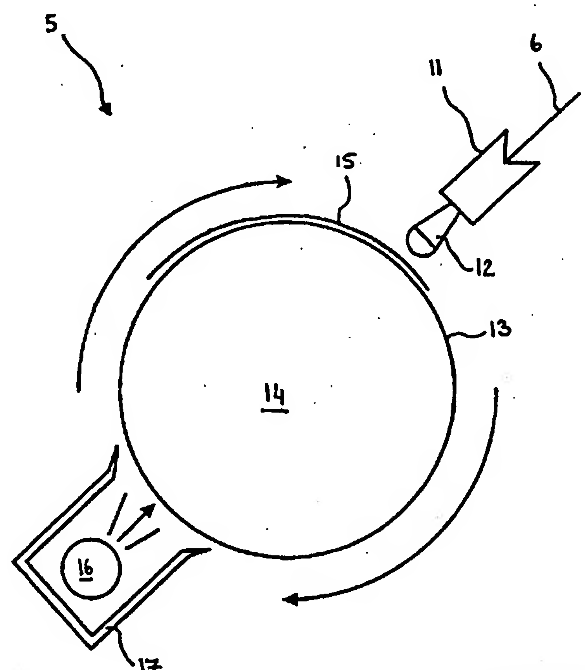

FIGURE 2.

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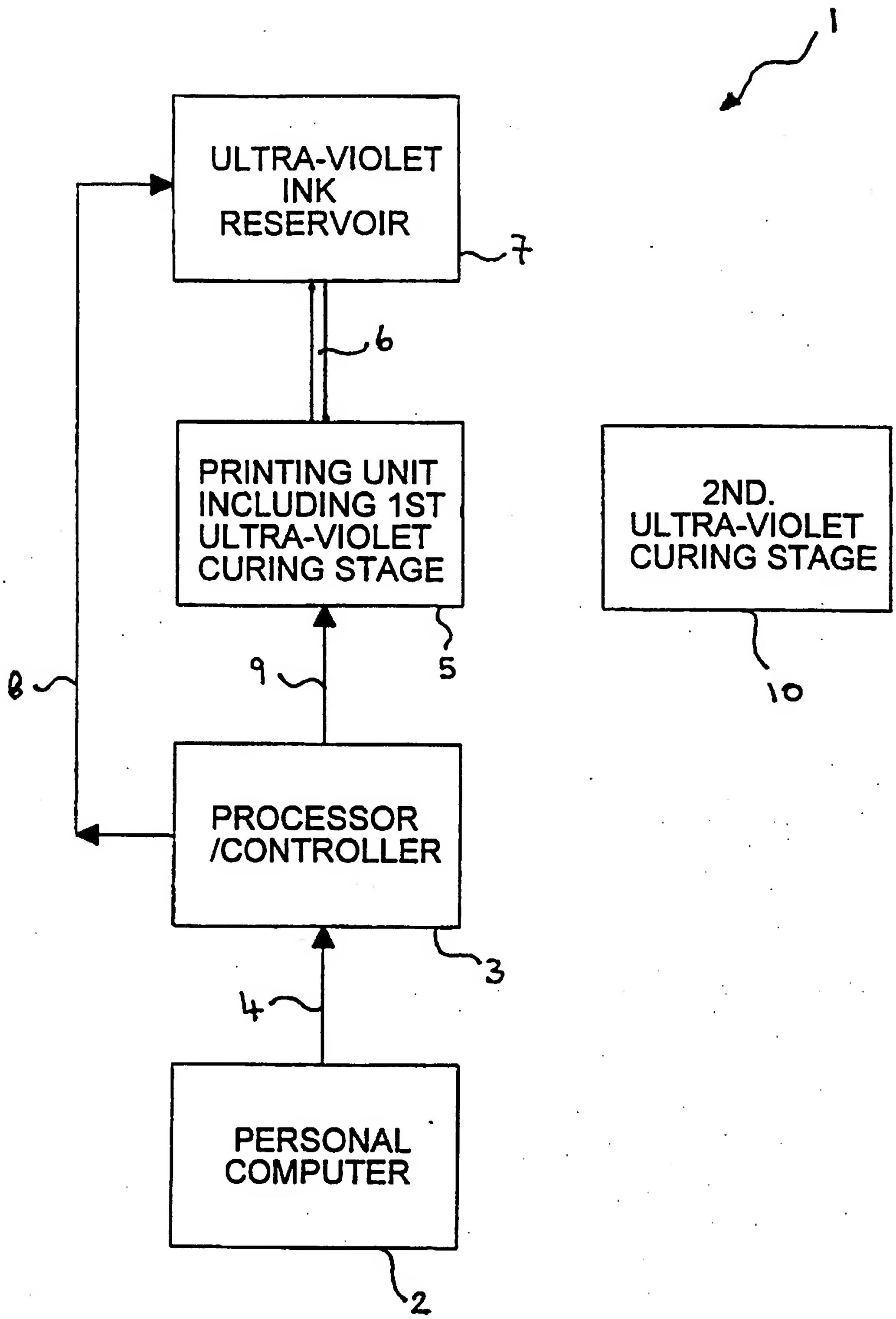
1
ULTRA-VIOLET INK RESERVOIR
7
6
PRINTING UNIT INCLUDING 1ST ULTRA-VIOLET CURING STAGE
5
2ND. ULTRA-VIOLET CURING STAGE
10
8
9
PROCESSOR /CONTROLLER
3
4
PERSONAL COMPUTER
2

FIGURE 1.

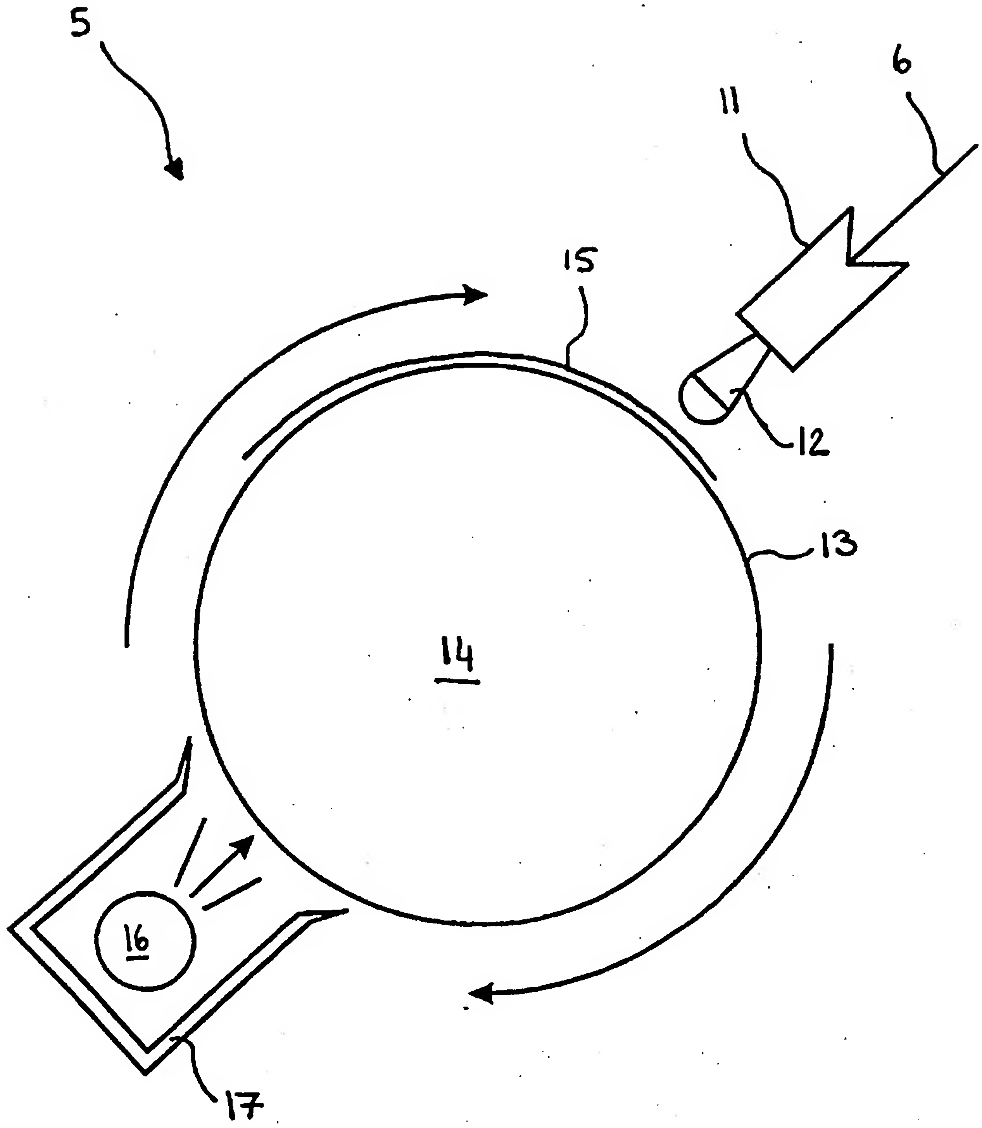

FIGURE 2.

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Ink Jet Printing System and Method of Printing

The present invention relates to an ink jet printing system and to a method of printing using such a system. In particular, it relates to a ink jet printing system employing direct digital colour printing technology.

Direct digital colour printing requires an operator to create a colour image on a personal computer running industry standard digital imaging software. Digital data representing the image is fed to a printing machine via a processing unit which formats the data and controls the printing machine to print an image corresponding to the image created on the computer, on a print substrate.

One conventional type of direct digital printing machine or digital colour proofing system uses a print head in which a fixed or movable array of piezo-electric or thermally controlled ink jets are arranged equidistantly spaced from and facing the curved surface of a rotatable drum or cylinder around which the print substrate is wrapped face up. The drum rotates and is heated to dry out any moisture contained in the substrate. As the substrate passes beneath the print head the ink jets are controlled, by a processing unit which receives data representing the image from a computer running colour management system software such as hexochromatic or CMYK, to eject droplets of ink of a particular colour onto the substrate facing the ink jets. The substrate remains on the drum as it rotates so that each time it passes beneath the print head, a different colour ink is ejected from the ink jets to build up the final multi-coloured printed image on the substrate. When the printing process is complete, the printed substrate is removed from the drum and transported by carriage rollers to a dry-finish tray, similar to that found in a photocopier, where the image is fixed on the substrate. The process is then repeated with a fresh substrate. A typical machine of this type is the Dryjet Advanced Digital Colour Proofing System manufactured by Dantex Graphics Limited of Danon House, 5 Kings Road, Bradford, West Yorkshire BD2 1EY, which is supplied with digital data representing

an image from a computer running a CMYK colour management system with Adobe Postscript Level 2 software.

Digital colour proofing machines of the type described above are known for use in printing onto substrates made from absorbent materials, such as paper, using wax or pigment based inks. The substrate must have good absorption characteristics so that it is receptive to the ink which keys to, or sinks into, its surface where it dries quickly without running or smudging of the image during application of further ink colours or subsequent handling after the printing process is complete.

A disadvantage with the printing machine described above is that it is not possible to print an image onto a substrate made from a non-absorbent material, such as clear gloss or textured plastic sheeting, because the ink will not key or stick to the substrate and instead forms globules which tend to run or travel easily over its surface. Even if the ink is sufficiently cured on the substrate after the printing process and a backup ink applied to the substrate behind the non-scratchproof printed image in an attempt to stabilise it, the ink readily de-laminates or peels away from the substrate surface.

At present, the aforementioned problem is overcome by printing onto an absorbent substrate, such as paper, and then subsequently over-laminating the printed substrate with a plastics layer or coating to obtain the desired finish. Alternatively, the surface of the plastics or vinyl substrate to which ink is to be applied is pre-treated to render it receptive to the ink. One commonly used pre-treated substrate is the "Sigma range ink jet media" manufactured by Autotype International Limited, Grove Road, Wantage, Oxon OX12 7BZ. However, both techniques result in a product having inferior quality which is not sufficiently durable for the majority of applications. Furthermore, neither method is cost effective as additional processing steps are required either before or after the printing process, increasing production time and manufacturing complexity.

An additional problem is that the wax based ink is supplied in a solid form and must be heated to liquefy it to render it suitable for use. Although the ink cools quickly when it is ejected from the ink jets, avoiding heat damage to a paper or pre-treated substrate surface, the temperature of the ink and the machine components can still be sufficiently high enough to cause damage, such as deformation or wrinkling, to a substrate made from untreated plastics material.

In the electronics industry membranes are used to cover the control buttons on vending machines, photocopiers and similar equipment. The membranes are manufactured by printing information or labels representing different functions of the machine onto a substrate using a screen printing process. Although sample proofs of membranes have been made using a digital colour printing system, they are not sufficiently durable and only have a very limited life span.

It will be apparent from the foregoing that there is a need for a jetted printing system which can successfully print different coloured inks onto substrates made of non-absorbent materials such as clear gloss or textured plastics sheeting such as polyesters and polycarbonates without any substrate pre-treatment or subsequent lamination steps.

It is an object of the present invention to overcome or substantially alleviate the problems discussed above.

An ink jet printing system according to the present invention includes a print head having an ink jet for ejecting ultra-violet curable ink towards an untreated substrate made from a non-absorbent material, and a source of ultra-violet light for curing the ink on the substrate. The ultra-violet curable ink sticks or keys to the untreated substrate made from non-absorbent material and cures quickly when exposed to ultra-violet light. The nature of the ink pigmentation also provides it with good handling and colour flexibility. Furthermore, it need not be necessary to heat the ink for use, thereby avoiding damage to the print substrate. The use of ultra-violet curable ink is

also advantageous because it does not contain any organic solvents and therefore has no flashpoint.

The ink jet printing system, in accordance with a preferred embodiment, includes user input means for generating an image to be printed, processing means for receiving digital data representing the image from the user input means and for controlling operation of the ink jet in dependence on said data.

Preferably, the ink jet printing system of the invention includes storage means for storing a supply of ultra-violet curable inks of different colours and feeding means for supplying ultra-violet curable ink of a colour selected by the processing means to the print head.

The processing means preferably controls the feeding means to supply the print head with said selected ultra-violet curable ink.

Advantageously, the system includes a rotatably mounted drum having a cylindrical side wall for receiving the substrate, the print head being disposed with the ink jet facing the side wall.

The source of ultra-violet light is preferably positioned facing the side wall to irradiate the substrate and cure the ultra-violet curable ink ejected onto the substrate from the ink jet.

Conveniently, the source of ultra-violet light is movable towards or away from the side wall.

In one preferred embodiment, an additional source of ultra-violet light is provided for irradiating a substrate to complete the curing of the ultra-violet curable ink after removal of a substrate from the drum.

In one embodiment, the ink jet is movably mounted on the print head. Preferably, however the print head includes a fixed array of ink jets.

Piezo-electric ink jets are preferably used to eject ink onto the substrate. The "piezo" jets are most suitable as they do not rely on heat to deliver a droplet of ultra-violet curable ink onto the substrate, thereby avoiding damage to the substrate caused by the elevated temperature of the ink which may occur when thermally activated ink jets are used.

The present invention also provides a method of printing with an ink jet printing system comprising ejecting ultra-violet curable ink from an ink jet towards a substrate made from non-absorbent material and irradiating the substrate with ultra-violet light from a source to cure the ink on the substrate.

The method is preferably used with a substrate which has not been subjected to any pre-treatment.

The method preferably includes generating an image to be printed on user input means, processing digital data representing the image received from the user input means in processing means, and controlling the ink jet in dependence on said data.

In a preferred embodiment the method includes rotatably driving a drum having a cylindrical side wall, placing an untreated substrate onto the side wall of the drum, ejecting ink onto the substrate when the substrate passes beneath the ink jet during rotation of the drum and irradiating the substrate with ultra-violet light to cure the ultra-violet curable ink as the substrate passes beneath the source during rotation of the drum.

In one embodiment the method includes the step of removing the substrate from the drum and directing it beneath a remote additional source of ultra-violet light.

Additionally, an untreated substrate made from a non absorbent material printed with ultra-violet curable ink using the ink jet printing system and method according to the invention, is provided.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIGURE 1 illustrates a schematic diagram showing the component parts of the printing system according to the invention, and

FIGURE 2 illustrates the printing unit including the first ultra-violet curing stage shown in Figure 1.

Referring now to Figure 1 of the drawings, there is shown a schematic view of a direct digital colour printing system 1 comprising a personal computer 2 which is set up to run commercially available direct digital colour printing software using a hexachrome or CMYK colour management system, and on which an operator or designer can create an image to be printed.

The personal computer 2 converts the image into digital data and supplies it via a signal line 4 to a processing or control unit 3 which controls the operation of a printing unit 5. The processing unit 3 also manages the supply of ultra-violet curable ink to the printing unit 5 through an ink supply line 6 from a reservoir 7 which can contain up to eight differently coloured ultra-violet curable inks in separate chambers (not shown). The reservoir 7 includes an ink delivery control system (not shown) associated with each of the chambers which comprises a number of electronically controllable valves each independently openable or closable in response to a signal from the processing unit 3 to permit or restrict the flow of a selected ink colour from one of the chambers to the printing unit 5. The processing unit 3 is electronically connected to the ink delivery control system and the printing unit 5, via signal lines 8, 9, respectively.

The printing unit 5 includes a source of ultra violet light 16 (see Figure 2). A second source 10 of ultra-violet light is also located remote from the printing unit 5. The function and location of each of the ultra-violet light sources 10,16 will become apparent from the further description given below.

The printing unit 5 will now be described, with reference to Figure 2. The printing unit 5 includes a print head 11 which is fed with ultra-violet curable ink from the reservoir 7 via the ink supply line 6, as explained above. The print head 11 has an array of fixed ink jets or nozzles 12 and is disposed so that they face, and are equidistantly spaced from, a cylindrical wall 13 of a rotatably mounted drum 14 for receiving a substrate 15 to which ultra-violet curable ink is to be applied.

The ink jets are the commonly used piezoelectric ink jets in which a high voltage is applied to a piezoelectric crystal situated in a chamber containing the ink. The high voltage causes the piezoelectric crystal to deflect or bend to force a droplet of ink out of the chamber toward the substrate on the cylindrical wall 13 of the drum 14.

The ultra-violet light source 16 is in the form of one or more lamps and is arranged facing the cylindrical wall 13. The lamp is located on the opposite side of the drum 14 to the ink jets 12 so that they face each other with the drum 14 positioned between them. This prevents ultra-violet light irradiated from the lamp 16 from reaching the ink jets 12, which would cause the ink to cure before it has been ejected from the ink jets 12 onto the substrate 15. The lamp 16 is located in a lamp housing 17 to direct the majority of the ultra-violet light towards the cylindrical wall 13 and to support and protect the lamp 16 from damage.

The lamp housing 17 is mounted in a carriage (not shown) which enables the lamp 16 to be moved closer to, or further away from, the cylindrical wall 13 to vary the intensity or amount of ultra-violet light incident on the cylindrical wall 13. The intensity of the light emitted from the lamp 16 is also adjustable.

The printing unit 5 includes apparatus (not shown) for feeding a substrate 15 onto the cylindrical wall 13 of the drum 14 and for retaining or gripping it so that it remains in position on the wall 13 whilst the drum 14 rotates. Apparatus (not shown) is also provided to remove the substrate 15 from the cylindrical wall 13, when the application of ink to the substrate 15 has been completed, and to direct it beneath the second remote source 10 of ultra-violet light.

The substrate 15 is a sheet of untreated clear gloss or textured plastics material. Examples of suitable materials from which the substrate 15 may be made are Lexan Polycarbonate, Staufen MRPVC, clear PVC, Autotype matt polyester or polystyrene.

One of the many suitable ultra-violet curable inks are the Uvispeed UX range manufactured by the Sericol Group Limited of Westwood Road, Broadstairs, Kent CT10 2PA.

Operation of the ink jet printing system will now be described. An operator or designer creates the required multi-coloured image to be printed on the personal computer 2 using the direct digital colour printing software. When the image is complete, the image is converted into digital data by the computer 2 and fed via the signal line 4 to the processing unit 3. The processing unit 3 then controls, in dependence on the digital data received from the computer 2, the supply of ultra-violet curable inks to the print head 11 and subsequently the ink jets 12, and the operation of the required ink jets 12 to eject ultra-violet curable ink of a selected colour onto a substrate 15 to print the image corresponding to the image created on the computer 2.

The substrate 15 is fed, one sheet at a time, face down onto the cylindrical wall 13 of the drum 14 by the feeding apparatus (not shown) and is retained wrapped around the drum by the retaining apparatus (not shown). The drum 14 is rotatably driven so that the substrate 15 passes beneath the print head 11. As it does so, the processor 3 controls the ink jets 12 to eject minute droplets of ultra-violet ink of a first colour

selected by the processor in dependence on the digital data received from the computer 2, onto the substrate 15 in the correct location. Once the substrate 15 has passed the print head 11, continued rotation of the drum 14 causes the substrate 15 to pass the ultra-violet lamp 16. The ultra-violet light irradiated from the lamp 16 cures the ink sufficiently to prevent it from smudging, running or otherwise travelling across the substrate 15 before the next coloured ink can be ejected from the ink jets 12. This initial curing stage is known as "flash" curing and is just sufficient to make the droplets of ultra-violet curable ink resist travel as the substrate 15 revolves on the drum 14.

Each time the substrate 15 passes beneath the print head 11, ultra-violet curable ink of a different colour is ejected from the ink jets 12 and the substrate is subsequently exposed to the ultra-violet lamp 16 on each rotation of the drum 14 to cure the ink before the next colour is applied. The hexochromatic or CMYK colour management system typically employed in direct digital colour printing systems is capable of controlling the application of eight differently coloured inks. If the image to be printed includes all the available colours, the drum will rotate for approximately seven minutes to complete a full cycle.

Once the image is complete, the substrate 15 is lifted from the drum 14 by the removing apparatus (not shown) and directed to the second stage curing process in which the ultra-violet curable ink is directed beneath the second remote source 10 of ultra-violet light. The substrate 15 travels much more slowly as it passes beneath the second source 10 compared to when it is on the drum 14 to ensure that the ink is permanently fixed or cured on the substrate 15 by the second source 10.

As the substrate is removed, a fresh unprinted substrate is fed onto the drum to take its place, and the printing process is repeated.

In one alternative embodiment, the second source 10 of ultra-violet light may be omitted altogether, in which case the source of ultra-violet light 16 is used to

completely cure the ultra-violet curable ink on the substrate 15.

In a third embodiment, the ultra-violet light source 16 is mountable at any location around the circumference of the drum so that its position may be altered to enable the time interval between the actual ejection of ink onto the substrate and the irradiation with ultra-violet light to be changed. In this embodiment, the print head and/or the source of ultra-violet light are shielded to prevent the light from reaching the ink jets.

In a fourth embodiment, the drum is omitted and a flat-bed shuffle printing system is employed in which the substrate is fed onto a flat surface before ink is ejected onto it from an ink jet on a print head mounted adjacent to the surface. The substrate is then irradiated with ultra-violet light from a source to cure the ink before being lifted off the surface and replaced with a fresh substrate.

Although piezo-electric ink jets are used in the preferred embodiment, it is envisaged that other types of ink jet may also be used such as thermal or bubblejet. However, the temperature of the ink must be precisely controlled to avoid damage to the untreated plastics substrate when these alternative types of ink jet are employed.

Embodiments of the invention can be arrived at by modifying the Dryjet Advanced Digital Colour Proofing System manufactured by Dantex Graphics Limited, mentioned previously.

It will be appreciated from the foregoing that the printing system of the present invention provides a modified ink jet printing process which can be used in a direct digital colour printing system to enable ink to be successfully applied to non-absorbent materials such as clear gloss or textured plastics materials that have not been pre-treated although pre-treated materials could be used if desired.

Claims

1. An ink jet printing system including a print head having an ink jet for ejecting ultra-violet curable ink onto an untreated substrate made from a non-absorbent material, and a source of ultra-violet light for curing the ink on the substrate.

2. An ink jet printing system according to claim 1, including user input means for generating an image to be printed and processing means for receiving digital data representing the image from the user input means and for controlling operation of the ink jet in dependence on said data.

3. An ink jet printing system according to claim 2, including storage means for storing a supply of ultra-violet curable inks of different colours and feeding means for supplying ultra-violet curable ink of a colour selected by the processing means to the print head.

4. An ink jet printing system according to claim 3, wherein the processing means controls the feeding means to supply the print head with said selected ultra-violet curable ink.

5. An ink jet printing system according to any of claims 2 to 4, including a rotatably mounted drum having a cylindrical side wall for receiving the untreated substrate, the print head being disposed with the ink jet is facing the side wall.

6. An ink jet printing system according to claim 5, including transport means for feeding an untreated substrate onto the side wall of the drum, and gripping means for retaining the untreated substrate on the drum during rotation.

7. An ink jet printing system according to claim 5 or 6, wherein the source of ultra-violet light is positioned facing the side wall to irradiate an untreated substrate

and cure the ultra-violet curable ink ejected onto an untreated substrate from the ink jet.

8. An ink jet printing system according to claim 7, wherein the source of ultra-violet light is movable towards or away from the side wall.

9. An ink jet printing system according to any of claims 5 to 8, comprising a remote additional source of ultra-violet light for irradiating an untreated substrate to complete the curing of the ultra-violet curable ink after removal of an untreated substrate from the drum.

10. An ink jet printing system according to claims 5 to 9, wherein the source of ultra-violet light and the ink jet are arranged facing each other on opposite sides of the drum to prevent ultra-violet light from irradiating the ink jet.

11. An ink jet printing system according to any preceding claim, wherein the ink jet is movably mounted on the print head.

12. An ink jet printing system according to any of claims 2 to 10, wherein the print head includes a fixed array of ink jets.

14. An ink jet printing system according to any preceding claim, wherein the or each ink jet is a piezo-electric ink jet.

15. An ink jet printing system according to any preceding claim, wherein the source of ultra-violet light is at least one lamp of variable intensity.

16. A method of printing with an ink jet printing system comprising ejecting ultra-violet curable ink from an ink jet towards a substrate made from non-absorbent material and irradiating a substrate with ultra-violet light from a source to cure the ink on the substrate.

17. A method of printing according to claim 16, wherein the substrate is untreated.

18. A method according to claim 16 or 17, including generating an image to be printed on user input means, processing digital data representing the image received from the user input means in processing means, and controlling the ink jet in dependence on said data.

19. A method according to claim 18, including supplying ultra-violet curable ink of a colour selected by the processing means to the print head.

20. A method according to any of claims 16 to 19, including rotatably driving a drum having a cylindrical side wall, placing a substrate on the side wall of the drum, ejecting ink onto the substrate when the substrate passes the ink jet during rotation of the drum and irradiating the substrate with ultra-violet light to cure the ultra-violet curable ink as the substrate passes a source during rotation of the drum.

21. A method according to claim 20, including removing the substrate from the drum and directing it passed a remote additional source of ultra-violet light.

22. An untreated substrate made from a non absorbent material printed with ultra-violet curable ink by a method of printing according to any of claims 16 to 21.

23. An ink jet printing system substantially as hereinbefore described with reference to the accompanying drawings.

24. A method of printing with an ink jet printing system substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9812780.6
Claims searched: 1-24

Examiner: Gary Williams
Date of search: 23 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B6C: CSAD; B6F: FAN

Int Cl (Ed.6): B41J: 2/01; B41M: 7/00; H01B: 13/00

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,E	GB 2322597 A	(NCR) See Fig.1, page 4 line 24 - page 5 line 14, page 6 lines 25-28	1,16
X	WO 97/27053 A1	(TETRA LAVAL) See Figs.1&2, page 6 lines 1-13	1,2, 16-18,22
X	US 5237917	(AT INFORMATION) See Fig.1, col.5 lines 37-46, col.6 lines 11-15, col.8 lines 6-14	16
X	WPI Abstract Accession No. 96-185067/19 & JP 08060054 A (Canon) 05.03.96 (see abstract)		1,16,17 22

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.